**Designation: ~~D7223 – 17~~ D7223 – 21**

An American National Standard

# Standard Specification for Aviation Certification Turbine Fuel[1]

This standard is issued under the fixed designation D7223; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope*

1.1 This specification covers the use of purchasing agencies in formulating specifications for purchases of aviation turbine fuel under contract.

1.2 This specification defines one specific type of aviation turbine fuel for civil use in the certification of aircraft. The specification can be used as a standard in describing the quality of this aviation fuel from the refinery to the aircraft.

1.3 This specification does not include the fuels that are commonly used in aviation turbine engines. Those are listed in Specification D1655.

1.4 The aviation turbine fuel defined by this specification may be used in other than turbine engines that are specifically designed and certified for this fuel.

1.5 The use of EI/IP (Energy Institute/Institute of Petroleum) test methods is permitted. The user of this specification is referred to Specification D1655 (latest revision), Specification for Aviation Turbine Fuels, Paragraph 2, Referenced Documents and Table 1, Detailed Requirements of Aviation Turbine Fuels, Column 4, Test Methods, to determine the pairing of the IP test method with the particular detailed requirement, and to Section 11, Test Methods, to identify jointed standards and referee methods.



1.6 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6.1 *Exception*—Units of pressure are also given in psi.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D56 Test Method for Flash Point by Tag Closed Cup Tester
D86 Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure
D130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.J0.01 on Jet Fuel Specifications.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

D381 Test Method for Gum Content in Fuels by Jet Evaporation
D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
D1266 Test Method for Sulfur in Petroleum Products (Lamp Method)
D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
D1319 Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption
D1322 Test Method for Smoke Point of Kerosene and Aviation Turbine Fuel
D1655 Specification for Aviation Turbine Fuels
D1840 Test Method for Naphthalene Hydrocarbons in Aviation Turbine Fuels by Ultraviolet Spectrophotometry
D2386 Test Method for Freezing Point of Aviation Fuels
D2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry
D2624 Test Methods for Electrical Conductivity of Aviation and Distillate Fuels
D2887 Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography
D3227 Test Method for (Thiol Mercaptan) Sulfur in Gasoline, Kerosine, Aviation Turbine, and Distillate Fuels (Potentiometric Method)
D3241 Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels
D3242 Test Method for Acidity in Aviation Turbine Fuel
D3338 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
D3828 Test Methods for Flash Point by Small Scale Closed Cup Tester
D3948 Test Method for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer
D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter
D4057 Practice for Manual Sampling of Petroleum and Petroleum Products
D4171 Specification for Fuel System Icing Inhibitors
D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants
D4294 Test Method for Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry
D4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination
D4529 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
D4809 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)
D4952 Test Method for Qualitative Analysis for Active Sulfur Species in Fuels and Solvents (Doctor Test)
D5001 Test Method for Measurement of Lubricity of Aviation Turbine Fuels by the Ball-on-Cylinder Lubricity Evaluator (BOCLE)
D5006 Test Method for Measurement of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels
D5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
D5972 Test Method for Freezing Point of Aviation Fuels (Automatic Phase Transition Method)
D6378 Test Method for Determination of Vapor Pressure ($VP_X$) of Petroleum Products, Hydrocarbons, and Hydrocarbon-Oxygenate Mixtures (Triple Expansion Method)
D7042 Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.2 *Other Standards:*
AFRL-RQ-WP-TR-2013-0271 Determination of the Minimum Use Level of Fuel System Icing Inhibitor (FSII) in JP-8 that will Provide Adequate Icing Inhibition and Biostatic Protection for Air Force Aircraft[3]

## 3. Terminology

3.1 For definitions of terms used in this specification, refer to Terminology D4175.

## 4. General

4.1 This specification, unless otherwise provided, prescribes the required properties of aviation certification turbine fuel at the time and place of delivery.

## 5. Classification

5.1 One type of aviation turbine fuel is provided, as follows:

[3] Available from Defense Technical Information Center (DTIC), 8725 John J. Kingman Road, Ft. Belvoir, VA 22060–6218, http://www.dtic.mil/dtic, accession number ADA595127.

5.1.1 *Jet C-1*—A relatively wide boiling range volatile distillate.

## 6. Materials and Manufacture

6.1 Aviation turbine fuel, except as otherwise specified in this specification, shall consist of blends of refined hydrocarbons (see Note 1) derived from conventional sources including crude oil, natural gas liquid condensates, heavy oil, shale oil, and oil sands. The use of jet fuel blends, containing components from other sources, is permitted only on a specific, individual basis (see Annex A1 on fuels from non-conventional sources in Specification D1655).

NOTE 1—Conventionally refined jet fuel contains trace levels of materials which are not hydrocarbons, including oxygenates, organosulfur, and nitrogeneous compounds.

6.1.1 Fuels used in engines and aircraft are ultimately approved by the certifying authority subsequent to formal submission of evidence to the authority as part of the type certification program for that aircraft and engine model. Additives to be used as supplements to an approved fuel must also be similarly approved on an individual basis (see Specification D1655).

6.2 *Additives*—May be added to this aviation turbine fuel in the amount and of the composition specified in the following list of approved material:[4]

6.2.1 *Antioxidants*—In amounts not to exceed 24.0 mg/L active ingredients (not including mass of solvent):

6.2.1.1 2,6-ditertiary-butyl phenol.

6.2.1.2 2,6-ditertiary-butyl-4-methyl phenol.

6.2.1.3 2,4-dimethyl-6-tertiary-butyl phenol.

6.2.1.4 75 % minimum 2,6-ditertiary-butyl phenol, plus 25 % maximum mixed tertiary and tritertiary-butyl phenols.

6.2.1.5 55 % minimum 2,4-dimethyl-6-tertiary-butyl phenol, plus 15 % minimum 2,6-ditertiary-butyl-4-methyl phenol, remainder as monomethyl and dimethyl tertiary-butyl phenols.

6.2.1.6 72 % minimum 2,4-dimethyl-6-tertiary-butyl phenol, 28 % maximum monomethyl and dimethyl-tertiary-butyl phenols.

6.2.2 *Metal Deactivator Additive (MDA),* in amount not to exceed 2.0 mg/L (not including mass of solvent) on initial fuel manufacture at the refinery. Higher initial concentrations are permitted in circumstances where copper contamination is suspected to occur during distribution. Cumulative concentration of MDA when retreating the fuel shall not exceed 5.7 mg/L:

6.2.2.1 *N,N*-disalicylidene-1,2-propane diamine.

6.2.3 *Electrical Conductivity Additive*—Stadis 450[5] not to exceed 3 mg/L.

6.2.3.1 When loss of fuel conductivity necessitates retreatment with electrical conductivity additive, the following concentration limits apply:

| | | |
|---|---|---|
| At Manufacture: | | |
| | Stadis 450 | 3 mg/L, max |
| Retreatment: | | |
| | Stadis 450 | cumulative total 5 mg/L, max |

6.2.4 *Leak Detection Additive*—Tracer A (LDTA-A)[6] may be added to the fuel in amounts not to exceed 1 mg/kg.

[4] Supporting data (Guidelines for Approval or Disapproval of Additives) have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1125. Contact ASTM Customer Service at service@astm.org.

[5] Stadis 450 is a registered trademark marketed by Innospec Inc., Innospec Manufacturing Park, Oil Sites Road, Ellesmere Port, Cheshire, CH65 4EY, UK.

[6] Tracer A (LDTA-A) is a registered trademark of Tracer Research Corp., 3755 N. Business Center Dr., Tucson, AZ 85705.

6.2.5 Other additives are permitted. These include fuel system icing inhibitor and special purpose additives such as biocides. The quantities and types must be declared by the fuel supplier and agreed to by the purchaser. Only additives approved by the aircraft certifying authority are permitted in the fuel on which an aircraft is operated.

6.2.5.1 Biocidal additives are available for controlled usage. Where such an additive is used in the fuel, the approval status of the additive and associated conditions must be checked for the specific aircraft and engines to be operated.

6.2.5.2 *Fuel System Icing Inhibitor:*

*(1) Diethylene Glycol Monomethyl Ether (DIEGME)*, conforming to the requirements of Specification D4171, Type III, may be used in concentrations of 0.10 % to 0.15 % by volume.

*(2)* Test Method D5006 may be used to determine the concentration of DIEGME in aviation fuels.

6.3 Guidance material is presented in Appendix X3 of Specification D1655 concerning the need to control processing additives in jet fuel production.

## 7. Detailed Requirements

7.1 The aviation turbine fuel shall conform to the requirements prescribed in Table 1.

7.2 Test results shall not exceed the maximum or be less than the minimum values specified in Table 1. No allowance shall be made for the precision of the test methods. To determine conformance to the specification requirement, a test result may be rounded to the same number of significant figures as in Table 1 using Practice E29. Where multiple determinations are made, the average result, rounded according to Practice E29, shall be used.

7.3 If any additives are used, the aviation turbine fuel shall conform to the Table 2 listed requirements.

## 8. Workmanship, Finish, and Appearance

8.1 The aviation turbine fuel herein specified shall be visually free of undissolved water, sediment, and suspended matter. The odor of the fuel shall not be nauseating or irritating. No substance of known dangerous toxicity under usual conditions of handling and use shall be present, except as permitted in this specification.



## 9. Sampling

9.1 Because of the importance of proper sampling procedures in establishing fuel quality, use the appropriate procedures in Practice D4057 to obtain a representative sample from the batch of fuel for specification compliance testing. This requirement is met by producing fuel as a discrete batch then testing it for specification compliance. This requirement is not satisfied by averaging online analysis results.

9.2 A number of jet fuel properties including thermal stability, water separation, electrical conductivity, and others are very sensitive to trace contamination that can originate from sample containers. For recommended sample containers refer to Practice D4306.

## 10. Report

10.1 The type and number of reports to ensure conformance with the requirements of this specification shall be mutually agreed upon by the seller and the purchaser of the aviation turbine fuel.

10.2 A suggested form for reporting inspection data on aviation turbine fuel is given in Specification D1655.

## 11. Test Methods

11.1 Determine the requirements enumerated in this specification in accordance with the following ASTM test methods.

11.1.1 *Density*—Test Method D1298 or D4052. Test Method D4052 shall be the referee test method.

**TABLE 1 Detailed Requirements of Aviation Certification Turbine Fuel[A]**

| Property | | Jet C-1 | ASTM Test Method[B] |
|---|---|---|---|
| Acidity, total mg KOH/g | max | 0.10 | D3242 |
| Vol fraction of aromatics, cL/L | min/max | 8 to 25 | D1319 |
| Mass fraction of mercaptan sulfur,[C] cg/g | max | 0.003 | D3227 |
| Mass fraction of total sulfur, cg/g | max | 0.30 | D1266, D2622, D4294 or D5453 |
| Distillation temperature, °C (°F): | | | |
| Initial boiling point, temperature | min/max | 70/100 (158/212) | D2887, D86[D] |
| 5 % recovered, temperature | min/max | 80/110 (176/230) | D2887, D86[D] |
| 10 % recovered, temperature | min/max | 90/120 (194/248) | D2887, D86[D] |
| 20 % recovered, temperature | min/max | 105/140 (221/284) | D2887, D86[D] |
| 50 % recovered, temperature | min/max | 150/195 (302/383) | D2887, D86[D] |
| 90 % recovered, temperature | min/max | 215/255 (419/491) | D2887, D86[D] |
| Final boiling point, temperature | min/max | 240/290 (464/554) | D2887, D86[D] |
| Flash Point, °C (°F) | report | | D56, D3828 |
| Density at 15 °C, kg/m$^3$ | | 750 to 840 | D1298, D4052 |
| Vapor pressure[E] | | | |
| at 25 °C, kPa (psi) | report | 3.0 (0.44) to 5.5 (0.80) | D6378[F] |
| at 38 °C, kPa (psi) | report | 5.6 (0.8) to 8.2 (1.2) | D6378[F] |
| at 50 °C, kPa (psi) | min/max | 10.0 (1.45) to 12.5 (1.82) | D6378[F] |
| at 100 °C, kPa (psi) | report | 56 (8.1) to 60 (8.7) | D6378[F] |
| Freezing point, °C | max | -35 | D2386, D5972[G] |
| Viscosity at –20 °C, mm$^2$/s[H] | max | 8.0 | D445, D7042[I] |
| Net heat of combustion, MJ/kg | min | 42.8[J] | D4529, D3338, or D4809 |
| One of the following requirements shall be met: | | | |
| (*1*) Smoke point, mm, or | min | 25 | D1322 |
| (*2*) Smoke point, mm, and | min | 18 | D1322 |
| Naphthalenes, vol, % | max | 3.0 | D1840 |
| Copper strip, 2 h at 100 °C | max | No. 1 | D130 |
| Thermal stability: | | | |
| (2.5 h at control temperature of 260 °C min): | | | |
| Filter pressure drop, mm Hg | max | 25 | D3241[K] |
| Tube deposit less than | | 3 | D3241 |
| | | No *Peacock* or *Abnormal* Color Deposits | |
| Existent gum, mg/100 mL | max | 7 | D381 |
| Microseparometer,[L] Rating | max | 1b | D3948 |
| Without electrical conductivity additive | min | 85 | |
| With electrical conductivity additive | min | 70 | |
| Lubricity[M] – BOCLE WSD, mm | max | 0.85 | D5001[M] |
| ~~Additives:~~ | | | ~~see 5.2~~ |
| Additives: | | | see 6.2 |
| Electrical conductivity, pS/m | required | 50 to 600 | D2624 |
| Other | optional | | |

[A] For compliance of test results against the requirements of Table 1, see ~~6.2~~7.2.
[B] The test methods indicated in this table are referred to in Section ~~10~~11.
[C] The mercaptan sulfur determination may be waived if the fuel is considered sweet by the doctor test described in Test Method D4952.
[D] If Test Method D2887 is used, use correlation procedure (Appendix X5) in Test Method D2887 to convert D2887 temperatures to D86 equivalent temperatures. Both minimums and maximums shall be met.
[E] Absolute vapor pressure (VPx) is the primary property to be controlled; 2,2 dimethylbutane and toluene, as cited in Section 11 and Note 14 of Test Method D6378 – 08, shall be used as verification fluids. 1.0 kPa = 0.145 psi.
[F] Latest version. Record absolute vapor pressure (VPx).
[G] Test Method D5972 may produce a higher (warmer) result than that from Test Method D2386. In case of dispute, Test Method D2386 shall be the referee method.
[H] 1 mm$^2$/s = 1 cSt.
[I] Test Method D7042 results shall be converted to bias-corrected kinematic viscosity results by the application of the correction described in the Precision and Bias section of Test Method D7042 for jet fuel at –20 °C.
[J] Use either Eq 1 or Table 1 in Test Method D4529 or Eq 2 in Test Method D3338. Test Method D4809 may be used as an alternative. In case of dispute, Test Method D4809 shall be used.
[K] Tube deposits shall always be reported by the Visual Method.
[L] At point of manufacture.
[M] Lubricity test can be waved with purchaser's agreement.



11.1.2 *Distillation*—Test Method D86 or D2887 with the conversion to D86 temperatures given in correlation procedure (Appendix X5) in Test Method D2887.

11.1.3 *Vapor Pressure*—Test Method D6378. Record absolute vapor pressure (VPx).

11.1.4 *Flash Point*—Test Method D56 or D3828. Test Method D3828 shall be the referee test method.

11.1.5 *Freezing Point*—Test Methods D2386 or D5972. Test Method D2386 shall be the referee test method.